Space Weather Technical Forecast

Issued on Tuesday, 05 September 2023 at 13:02 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of R1 throughout, increased from midweek UTC. Probable peak Slight Chance G1 in current UTC day, however possible CME awaiting analysis.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity rose to Moderate in the past 24 hours, with GOES16 and 18 recording a peak M2.0 flare recorded from AR3421 near centre-disc at 05/0812UTC. This was followed by a smaller C7.1 from a possible new arriving region over the northeastern limb. There are now up to eight sunspot groups on the disc - the most dynamic being AR3421, AR3422 and AR3423. The large and central AR3421 was responsible for the peak flare and showed a spreading tendency, with some development of intermediate spots, shear and some polarity mixing, with candidates for very faint Mt Wilson deltas perhaps beginning to form. AR3423 showed rapid growth, with multiple spots emerging, although the narrow viewing angle is hampering analysis. Finally, AR3422 showed a spreading and fading trend.

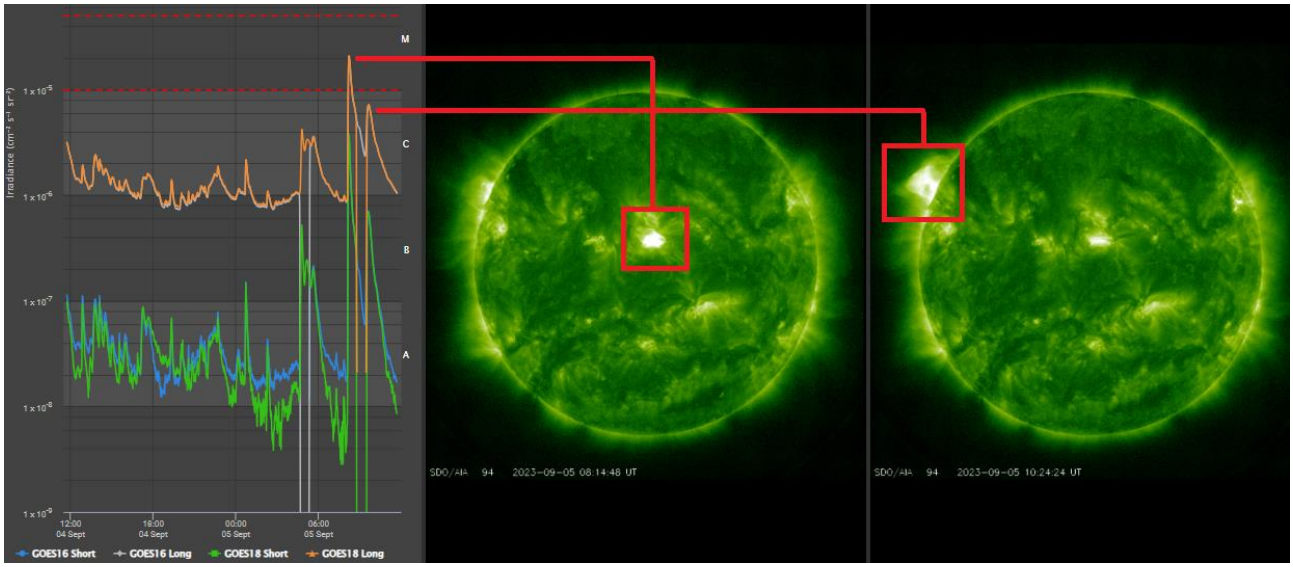

Figure 0: GOES16 and 18 X-ray trace showing the largest X-ray flare events of the period and their source locations. The aftermath of the larger of the two events may yet reveal a CME, however there remains no clear evidence as of the time of issue of this guidance document.

There was a Coronal Mass Ejection (CME) seen leaving the southeastern quadrant near S20E70 at 04/1330UTC. This event has been modelled, and the bulk of ejecta appear to miss, with perhaps some very minor contribution from the shock in the UTC day 07 into 08 September. The peak flare of the period may yet prove to have been accompanied by a second CME, with this much more likely to have an Earth-directed component should it manifest on coronagraphs. Tentatively then, there are no significant new CMEs

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Solar Wind / Geomagnetic Activity: The solar wind environment was indicative of the cessation of the fast wind from CH40/+ with speeds reducing from near 425km/s into the high 300s, accompanied by a faltering phi angle that was previously only weakly aligned away from the Sun (positive). The solar wind density showed a level trend within the long term background of single-figures ppcc, while the IMF was smooth and peaked below 6nT, with the north-south component ranging between +/-4nT.

The net result of the above solar measures was for provisionally Quiet geomagnetic activity throughout.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux has been at Background levels throughout.

GOES16 high energy (greater than 2MeV) electron flux was at Moderate levels, with a peak of 514pfu at 04/1545UTC. The associated 24-hour fluence was below the Active threshold, on a falling then rising trend, with 1.65e7 integrated pfu observed at 05/0001UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: There is a daily Chance of M-class flares that increases slightly from midweek with the arrival of a returning active region, coupled with the increased complexity of AR3421.

Solar Wind / Geomagnetic Activity: There are numerous aspects to the geomagnetic forecast, but the main watch point is whether any CME resulted from the M2.0 flare of the current UTC day. This excepted, the forecast is of a peak Slight Chance of G1 within the current UTC day from CH42's fast wind and perhaps a glance from the 01 September CME. Activity should then reduce later in the UTC working week.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux is Expected to remain at Background levels.

High energy (greater than 2 MeV) electron flux carries high uncertainty, and although an initial rise in diurnal flux is likely, this should soon be attenuated at GEO. Any recovery is low confidence, but on balance should perhaps most likely remain below Active throughout.

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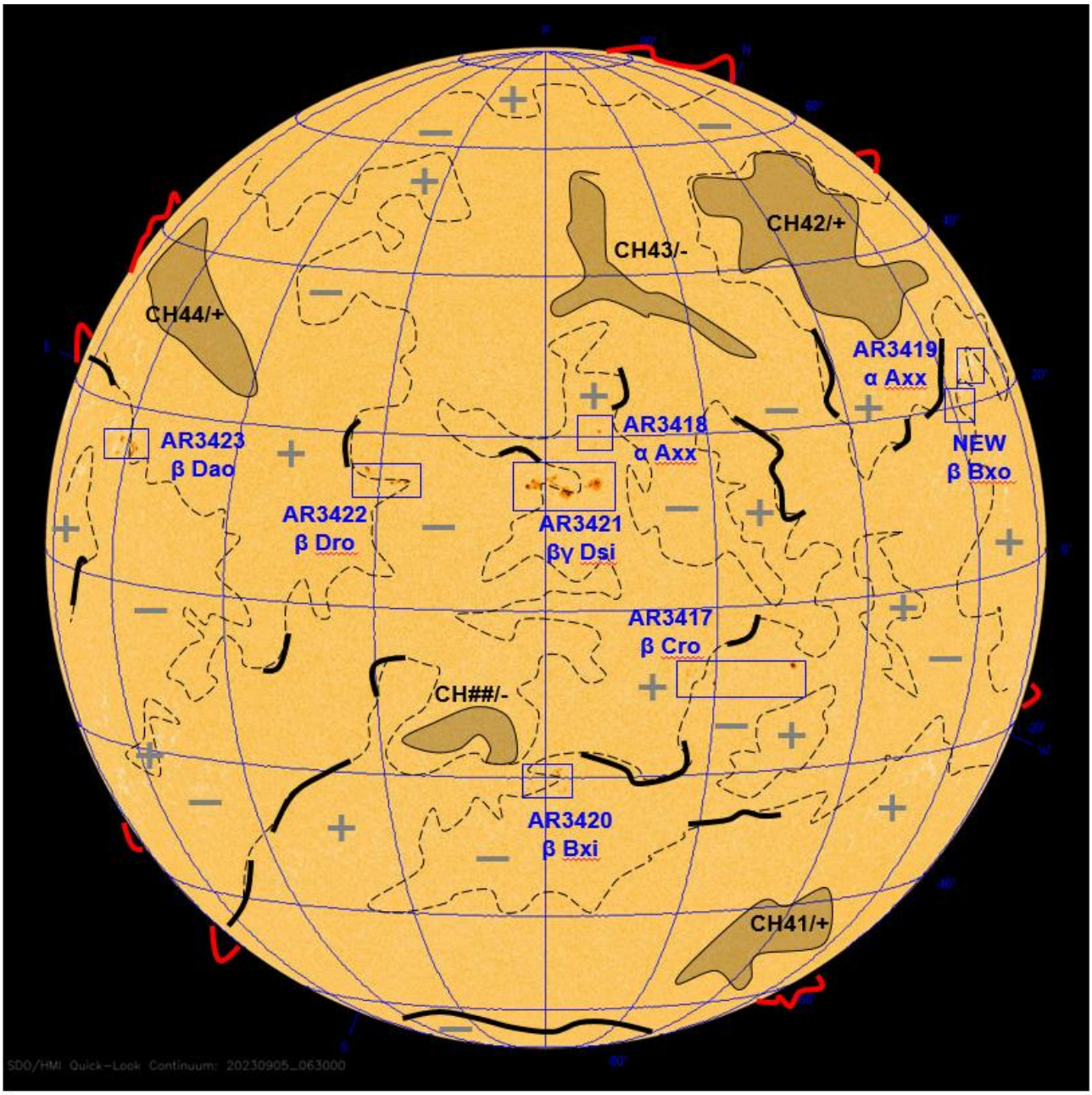
Figure 1. Solar Analysis Valid 05/0630UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:

This forecast period comprises an imminent fast wind from CH42/+, followed by a late-week lull ahead of CH43/- to perhaps close the four day period. The earlier fast wind is expected to be the more marked event given Earth reaches its annual zenith above the solar equatorial plane around day four (08 September), meaning more direct alignment in addition to its having positive polarity.

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In addition to the coronal hole forecast, there are some possible CMEs of note. Potentially the most noteworthy would be any event arising from the M2.0 flare from AR3421 at 05/0812UTC. There is not yet any clear signal from coronagraph imagery, there was no confirmed Type II and the dimming was modest; however the flare appeared to have a exponential decay over a long period before it was interrupted by the later northeastern limb event, meaning the jury remains out as to any impactful consequences on geomagnetism later this week.

This event excepted, the CME forecast consists of a possible glancing blow from a CME that left the sun late on 01 September, associated with a C7.3 flare from an area of plage in the southeast. The CME has been modelled as missing mainly below and behind Earth, but peripheral effects could be seen over the remainder of the current UTC day. Added to this is a still lower confidence event in a glance from the shock from the 04/1330UTC southeastern quadrant filament eruption. The latter event in particular is likely to be swamped by any incumbent fast wind effects, and negligible activity should result.

In summary, in the absence of any M2.0 CME, the geomagnetic forecast should show a peak Slight Chance of G1 in the current UTC day, with a slight vestigial tail into day two should it arrive late. There is then a further damped risk of G1 from any contribution from CH43/- later in the four days, although as states this will very likely be the smaller of the events.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	20	5	5	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
02/0427	Partial	Flare	SE (Plage)	605km/s	Imminent	Slight chance of glancing impact.
04/1330UTC	Partial	Flare	SE (Plage)	1025km/s	Overnight 07 into 08 September	Slight glance of shock, negligible impacts

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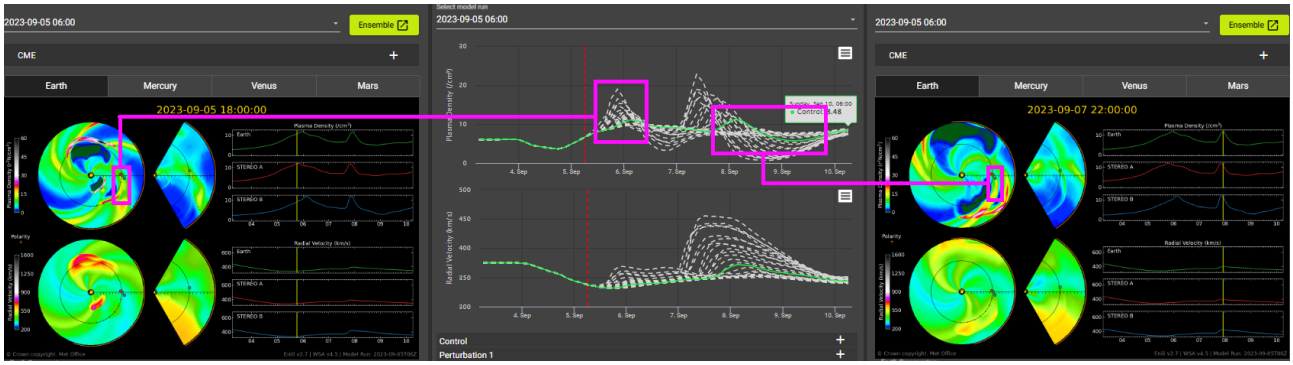

Figure 2: 06UTC MOSWOC Enlil runs and ensemble showing two simulations paused at the time of the 01 September CME and 04/1330UTC CME crossing 1AU. The latter is especially low confidence, as outlied by the very broad range of ensemble output. This run does not feature any M2.0 CME from 05 September.

Radio Blackouts - X-Ray Flares:

The X-ray flare forecast is dominated at present by AR3421, which is a growing region currently crossing the solar meridian as a Dsi/Beta-Gamma. The central spots of this group in particular are in a state of flux, and when coupled with a slight increase in overall area and a spreading trend make this one to watch. In addition to this group, AR3423 in the northeast has shown a rapid growing trend over the same period. This appears as a Dao/Beta at present, however the narrow viewing angle is likely to be masking detail.

No significant regions are expected to depart the disc in the period, however there are already signs from far-side soundings, Mars Persistence rover solar images as well as persistence that Ex-AR3403 may have survived its far-side transit to deliver the C7.1 observed in the current UTC morning.

The evidently sizeable arriving region and the current trend towards increasing complexity in AR3421 are the reasons for the increase in X-ray flare risk from the middle of the current UTC working week, with this then persisted for the remainder of the four days.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**R1-R2 M Class**	Yes	30	40	40	40
Very Active	**R3 to R5 X Class**	No	1	2	2	2

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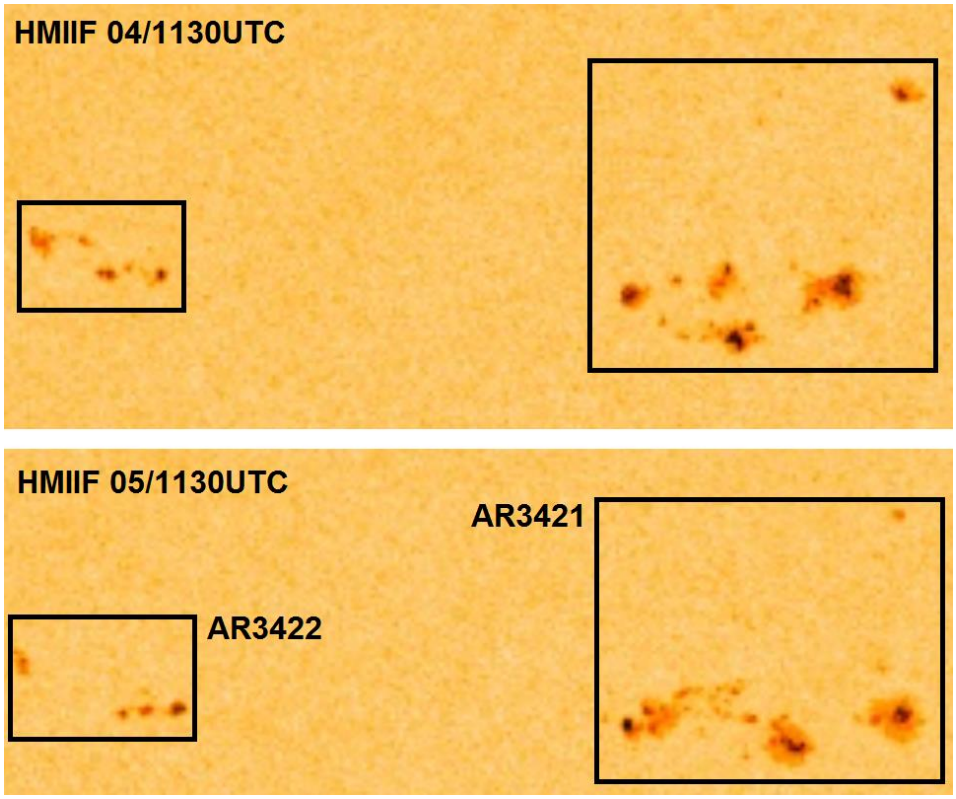
Figure 3: 24-hour changes observed in two centre-disc sunspot regions in the period: the potent AR3421 and the decaying AR3422.



Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 is within Background levels, and now very near its typical resting level in the wake of the S1 enhancement that greeted September. There has not yet been any response from the current UTC morning's M-class flare, and any excedence of S1 is considered unlikely given its position near the meridian.

There is a nominal slowly increasing daily Slight Chance of an enhancement should any significant flares occur, with these most likely from AR3421 and perhaps rapidly-growing AR3423.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	2	2	2	5
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

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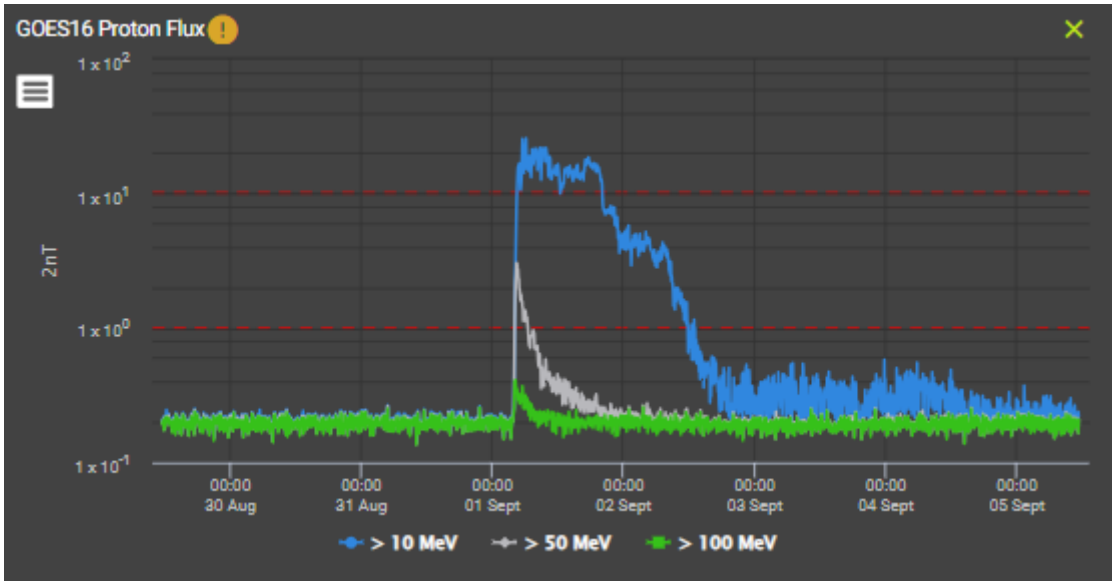
Figure 4: Past week in GOES16 high energy proton flux. The S1 enhancement from the 01 September is now very nearly entirely decayed, with 10MeV fractionally above their resting background level. The chances of similar occurences increase in the four days but are judged as a Slight Chance.



High Energy Electrons Event (≥ 2MeV):

High energy (greater than 2 MeV) electron flux observed by GOES16 is currently at Moderate levels. A recent upward response following the easing of the solar wind pressure following CH40/+ has not yet resulted in any High levels of flux being observed.

Should current trends continue and not be interrupted by any fast wind or imminent glancing CME influence from the 01 September event, a relatively higher diurnal oscillation is expected, however given the possible twin onslaughts, some form of attenuation at GEO is likely, and the probabilities of Active fluence remain subdued.

There remains a chance of enhancements to the electron flux towards the end of the period, perhaps reaching High levels, though confidence in detail is currently low for this given up to two incident fast winds, and perhaps up to two CMEs.

The associated 24-hour fluence will most likely remain below the Active (1e8 integrated pfu) threshold throughout the period, but with greatly decreasing confidence with time - largely the rationale for the increased probabilities shown. MOSWOC REFM is not felt to be a reliable resource in the period given the possible presence of transients.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	1	10	20	25
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

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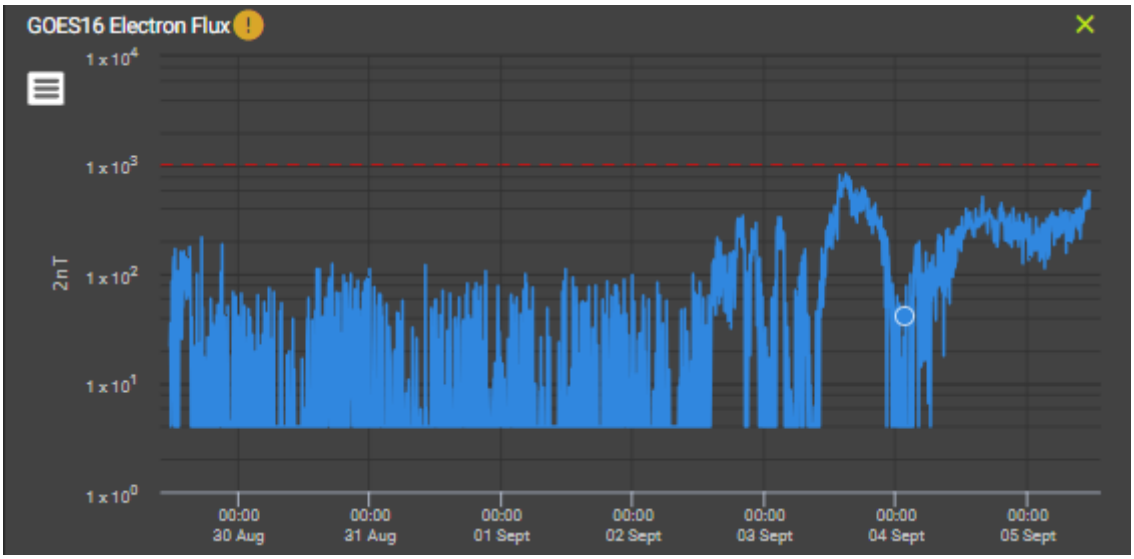
Figure 5: Past week in GOES16 high energy electron flux. There has been an increase in electron populations at GEO since geomagnetic activity from CH40/+ has waned, particulalrly in the past few hours. This trend is expected to be arrested within the current UTC day by an arriving fast wind and perhaps a CME, with an uncertain recovery later in the UTC working week.



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